

Research News and Comment

Learning Anytime, Anywhere: Advanced Distributed Learning and the Changing Face of Education

by J. D. Fletcher, Sigmund Tobias, and Robert A. Wisher

The Advanced Distributed Learning (ADL) initiative was undertaken to make education, training, and lifelong learning accessible at any time, anywhere. It has developed specifications and techniques that are being adopted globally by governments, businesses, and schools. Although ADL currently focuses on government and business applications, it has significant implications for the classroom structures, processes, and activities of K-16 education. The authors describe the ADL initiative and its implications for K-16 education and call for increased attention from educators and education researchers to the opportunities and challenges represented by anytime, anywhere, distributed learning.

Keywords: accessible learning; distributed learning; educational technology; individualized instruction; learning objects; Web-based learning

The purpose of the Advanced Distributed Learning (ADL) initiative is to make learning accessible at anytime, anywhere in the world. It was undertaken by the U.S. Department of Defense to develop instructional capabilities for itself and for other federal agencies, which can use or adapt ADL to their own needs. This article describes the ADL initiative and discusses its relevance to K-16 educators and education researchers.

Learning in ADL refers both to education, such as that found in K-16 schools, and to training, such as that found in industry and government.¹ *Distributed* refers to delivery anytime and anywhere, including formal settings such as classrooms and schools but also homes, workplaces, museums, libraries, and community centers. *Advanced* refers to ADL's interactive and adaptive presentation of learning, which capitalizes on the capabilities of computer technology to adjust to the needs of individual learners.

Accessible Learning, ADL, and Education

By increasing the accessibility of instructional materials, ADL can enhance communication and cooperation between homes, communities, and K-16 schools. It can also help harmonize the learning processes and procedures of schools with those of our rapidly evolving workplaces and facilitate collaborative efforts by

students to investigate phenomena and solve problems. ADL can also help schools reach students with special needs, especially those who are homebound for any appreciable period of time or students who do not find the elective offerings they need. Perhaps most important, ADL can help schools gain access to instructional materials developed for reuse and sharing across industry and government. In a 2003 survey of instructional materials developed for industry and government, Rehak (2006) found that nearly 3 million ADL "objects" had been produced. More have been appearing steadily in the years since that survey was performed. We estimate that more than 6 million such objects are now available globally.

ADL provides opportunities and a need to address issues that may be of importance and interest to researchers. Among these are ways to collect, organize, and represent human knowledge by using technology and ways to assemble those representations into educational experiences, environments, and interactions of relevance and value to learners. There is much to be learned about how best to integrate the anytime, anywhere capabilities of ADL with current educational practices and institutions.

ADL's emphasis on access and individualization has proved to be attractive to industry and government. Its specifications for producing sharable instructional materials have been adopted globally. Thus far, however, ADL has received more attention from industry and the government than from educators and education researchers. That is why we seek to bring ADL to the attention of educators and education researchers for their consideration and review.

What Is ADL?

The ADL initiative focuses on the use of learning objects as a way to make instructional materials readily accessible. ADL instructional objects are digital, sharable, and reusable entities that can be used for learning and are available to learners anytime, anywhere—often, but not necessarily, on the World Wide Web. Web-based instruction is an important aspect of ADL, but ADL materials may be delivered by any means, not just online. The objects can be downloaded or otherwise accessed, used, and reused by learners for as many different purposes and in as many learning contexts as desired.

The instructional objects are held in repositories that are controlled by their developers. ADL specifications allow the objects

Educational Researcher, Vol. 36, No. 2, pp. 96-102

DOI: 10.3102/0013189X07300034

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to be identified and located globally but accessed only by those who observe the rules set by the object and repository developers. Roschelle and Kaput (1995) emphasized early the importance of helping educators secure the benefits being realized in business by enabling them to locate and access ADL objects already available in industry and government repositories. Instructional objects are the primary topic of books by McGreal (2004), Strijker (2004), and Wiley (2000).

ADL objects may range in size from entire courses to more granular assets, such as video clips, audio messages, single graphics, and animations. Gibbons, Nelson, and Richards (2000) pointed out that sharable objects are most useful if they are small enough to be accessed and reused without major modifications. They suggested that the objects can contain instructional content, strategies for individualizing instruction, administrative routines for managing student progress, and rules for administering computer-based tests and reporting on students' progress. Such content can be packaged in the form of reusable, sharable objects and made accessible by using ADL specifications, just as instructional content is now.

In practice, classroom teachers can locate and assemble instructional objects from the Internet or the Web for students to use individually, collaboratively, or under instructional guidance. Parents can access the same materials to see for themselves what students are learning in school or to pursue their own learning. Developers can locate and reuse objects for creating courses, assessments, and learning environments such as simulations and situated projects. Students themselves can access objects to help them learn what they need to know in solving problems and completing projects assigned to them individually or collaboratively.

An example of ADL instructional objects in mathematics can be viewed at http://www.academiccolab.org/resources/demos/slope_LO/index.swf. These objects were developed to help adults change careers and become teachers. The new teachers had completed college degrees and teacher education programs but were unprepared to pass the Praxis examination, required for licensure in some states. The Academic ADL Co-Lab in Madison, Wisconsin, developed 12 instructional objects to help individuals prepare for the mathematics section of the Praxis exam and also enhance their general competence in mathematics. These objects help new teachers understand Praxis questions, see the patterns behind the questions, and improve their mathematical skills in general. The objects may be completed anytime and anywhere and can be mixed, matched, and sequenced however an individual student or teacher wishes. Each object can stand alone or can be used together within an online or classroom-based course.

The ADL Vision

ADL is building toward a future in which human knowledge, held in instructional objects, is identified and collected from the global information grid (currently the Web) and is then assembled on demand for real-time interactions tailored to each learner's knowledge, goals, interests, and needs. We anticipate that learning in the future may take place through goal-driven, tutorial, and problem-solving conversations involving handheld (or perhaps worn) devices wirelessly linked to one another and to the global

information grid. These conversations would enable the mixed-initiative dialogues originally envisioned by Carbonell (1970), allowing either the learner or the computer-instructor to initiate topics and inquiries. The conversations could be aided and augmented by didactic lessons, tests, simulations, and other presentations, interactions, and learning environments chosen from the grid and assembled to meet each student's individual needs.

Research to support realization of this vision is proceeding, but further investigation is needed. Development of computer-based instructional dialogue has continued since the 1960s (e.g., Brown, Burton, & DeKleer, 1982; Carbonell, 1970), with much of it reviewed more recently by Graesser, Gernsbacher, and Goldman (2003). Research on the object-oriented programming techniques needed to assemble objects into useful procedures began in the 1960s (Dahl & Nygaard, 1966), and textbooks on the topic have been appearing since the 1980s (e.g., Cox, 1986).

The Semantic Web (Berners-Lee, Hendler, & Lassila, 2001), which is being developed under the auspices of the World Wide Web Consortium, is also a factor in ADL development (Devedzic, 2006; Dodds & Fletcher, 2004). It is intended to improve cooperation between computers and human beings by imbuing Web information, content, and objects with more meaning. Research is needed to determine how the Semantic Web can best be used to identify and expose semantic linkages between bodies of knowledge that may appear dissimilar; to create more precise, comprehensive, and substantive models of subject matter domains and learners' levels of mastery; and to link learner models to appropriate instructional objects.

ADL can incorporate student models of competence and achievement derived from their performance on instructional objects, just as other technology-based approaches to education have done for some time (e.g., Fletcher, 1975). These student models are intended to adapt instruction to the needs, abilities, and backgrounds of learners, and they remain a ripe area for research. Studies investigating how student models can best be used to improve learning, which student characteristics stored in the models are most useful, how to map prior knowledge onto current instructional objectives, and so forth, provide opportunities not only to advance the effectiveness of ADL but to advance the techniques and practice of instructional psychology in general.

We have speculated that fulfillment of the ADL vision would involve the widespread use of handheld (or perhaps worn) electronic personal learning associates that engage and access ADL instructional objects. These devices could be used by individuals learning alone, in networked collaborative learning, in classrooms, or at work. Most of the hardware technology needed to build these associates already exists, as can be seen in the convergence of technologies for cellular telephones, electronic organizers, digital cameras, video recorders, and music players in single handheld devices.

Research on the use of instructional objects is continuing (Fund for the Improvement of Post-Secondary Education, 2005; Wiley, 2000). Our hope is that ADL will help focus these efforts, unifying and integrating them toward the achievement of the future envisioned by the developers. Much needs to be done before this future arrives, but its fulfillment seems likely, given present trends in the development of advanced learning systems as discussed by Hill (2003), among others.

ADL Specifications

Sharable Objects

The instructional objects that ADL relies on are specified by the Sharable Content Objects Reference Model (SCORM). This model makes it possible for objects to be shared, used, and reused without requiring a standardized computer configuration, operating system, browser, authoring tool, or programming language. Instead, ADL allows developers to do what they believe is best within each object while requiring standardized procedures for communicating between objects. Among the criteria for SCORM were that its specifications should make instructional objects *accessible* to all learning systems; *interoperable* across all technology-based platforms, browsers, and instructional management systems; *durable* across evolving versions of underlying software tools and operating systems; and *reusable* in the development of new learning materials (Dodds, 2004; Dodds & Fletcher, 2004). Conforming to such specifications reduces both costs and time in materials preparation and increases the ability of designers, developers, instructors, and students to take full advantage of information and materials available on the global information grid.

SCORM is under continual development, but its current version can always be found at <http://www.adlnet.org>. Successive versions are increasingly able to accommodate a comprehensive variety of instructional approaches.

Accessing Sharable Objects

The effective identification and location of instructional objects are managed by the Content Object Repository, Discovery, and Registration/Resolution Architecture (CORDRA; Dodds & Fletcher, 2004; Rehak, Dodds, & Lannom, 2005). Both SCORM and CORDRA rely on metadata to specify and locate objects. Metadata are part of the digital packaging "wrapped" around the objects. They specify what is in the package and what the object is. CORDRA is built on existing standards and specifications, orchestrated and combined by ADL to provide shareability and interoperability along with visibility and access control.

ADL and Issues for Education and Education Research

To a degree, ADL has already begun to affect the instructional procedures and practices of education. For instance, about 185,000 K-12 students in South Korea are using ADL instructional objects daily as they participate in a home learning system. Examples of instructional objects in various fields, including business, health, and science, are part of a searchable database called Wisc-Online. That database contains several hundred objects authored by faculty in the Wisconsin Technical College System, a partner of the Academic ADL Co-Lab. The objects may be accessed online from nonprofit organizations worldwide at no cost to teachers or students. Wisc-Online had 543,628 unique visitors between January and December 2006, with 18,286,387 total hits. All learning objects have been reviewed by peers and rated by users. One of the Wisc-Online learning objects, "Construction of a Cell Membrane," was awarded the Pirelli International Award in May 2006, in Rome. That object and all the others in the database may be examined at <http://wisconline.org/>.

An essential component of the ADL vision is tailoring instruction to learners' needs and capabilities. Reviews of relevant research (Andrews & Bell, 2000; Cronbach, 2002; Gustaffson & Undheim, 1996; Tobias, 2003, 2005) have all found that prior domain knowledge is a key element in such tailoring. In general, the findings have long shown that students with lower levels of prior knowledge require substantial instructional support, such as modified organization of the content, increased feedback, and provision of practice and prompts (Tobias, 1982). Students with more prior knowledge have been found to require less support of these kinds.

ADL objects can store indexes of learners' prior knowledge and their progress toward instructional objectives. As a student progresses, a representation of his or her mastery and progress is created by the learning system to tailor successive instructional interactions more precisely to the student's needs. The objects can also store other characteristics that can be used to individualize instruction, such as motivation, attitude, personality indexes, and metacognitive skills (Christensen, Anakwe, & Kessler, 2001; Strijker, 2004; Tobias, 2006). As indicated previously, research is needed to determine which of these characteristics is likely to be most useful for instructional adaptations.

Need for Technology

Is such adaptation worthwhile? As noted by Fletcher (1992, 1997, 2004) and others (e.g., Corbett, 2001), Benjamin Bloom (1984) laid down the gauntlet with his 2-sigma challenge. He compared the results of one-on-one tutoring with classroom instruction and found student achievement differences of 2 standard deviations (i.e., 2σ) favoring tutorial instruction. We cannot provide a single human tutor for every learner, but educational technologies, with their capabilities for tailoring instruction to individual students' needs while reducing per student instructional costs, make this educational imperative both affordable and globally accessible.

Reviews of research on educational technology (e.g., Fletcher, 2003, 2004; Kulik, 1994) suggest that its promise for the effective tailoring of instruction to individual needs is genuine and worthwhile. Educational computing gains do not yet routinely reach the 2-sigma level, but increases approaching 1 standard deviation are not uncommon, and some assessments (e.g., Gott, Kane, & Lesgold, 1995) have reported improvements in excess of 2 standard deviations.

In the future, ADL technologies may not simply mimic what human tutors do in adapting instruction to individual learners. They may add powerful, new, and different capabilities that supplement and modify what master tutors and instructors do to create effective, engaging learning environments. As with most technological developments, we may begin with an analogy based on current practice (mirroring the individualizing practices of human teachers) but finish with something entirely new and unexpected (e.g., mirroring the development of automobiles from horseless carriages or radio from wireless telegraph).

Affordability and Cost-Effectiveness

An assumption underlying ADL is that anytime, anywhere distributed learning may be made both affordable and accessible by technology. Issues of affordability and cost-effectiveness have

been addressed by research (Fletcher, Hawley, & Piele, 1990; Niemiec, Sikorski, & Walberg, 1989). For instance, Fletcher et al. (1990) assessed the costs needed to achieve a common instructional outcome: raising student scores on a standard test of mathematics by 1 standard deviation. They compared tutoring by professional tutors, peer tutoring, reducing class size, increasing instructional time, and using computer-based instruction. Their results suggested that the most cost-effective approaches were computer-based instruction and peer tutoring; of the two, computer-based instruction was more cost-effective.

A strong cost-effectiveness argument may therefore be made for combining peer tutoring with computer-based instruction by having two or more students on a single computer. These approaches have been shown to be effective (e.g., Brush, 1997; Mevarech, 1997) for a variety of reasons, many of which are based on the collaborative learning activity they produce.

Distance Learning, Web-Based Instruction, and ADL

Distance learning differs from distributed learning in that teachers are always physically separated from students in distance learning. Distributed learning includes distance learning, but the anywhere element in distributed learning includes classrooms in which teachers are present. Still, anytime, anywhere support for distance learning, often collaborative, by physically separated learners, including homebound learners, may be one of the more significant contributions of distributed learning.

In reviewing studies of distance learning, Wisher and Champagne (2000) found positive results for distance education compared with classroom instruction, but they also found significant methodological problems in many studies. A meta-analysis by Bernard, Abrami, Lou, and Borokhovski (2004) found similar results, including a small, though significant, effect favoring distance education. These results echo Russell's (1999) findings of no learning differences between distance instruction and classroom learning but a preference among students for the latter.

Although much distance instruction is delivered over the Web, unease about its quality persists, probably with justification. Olson and Wisher (2002) found Web-based distance instruction to be an improvement over classroom learning, but to a lesser degree than earlier examples of computer-based instruction (Kulik, 1994). Sitzmann, Kraiger, Stewart, and Wisher (2006) found Web-based instruction to be more effective than classroom instruction for teaching declarative knowledge when Web-based instruction incorporated synchronous human interaction and had a high level of learner control. When similar instructional methods were used, Web-based and classroom instruction were equally effective for teaching declarative knowledge.

Studies of Web-based instruction usually compare whole courses with learning in intact classrooms. Few have studied use of the Internet to enhance existing instructional environments. A promising role for ADL may be not to substitute for current instruction but to augment it. Research on the effectiveness of such augmentations is needed.

A recurring concern in distributed instruction delivered without the physical presence of a proctor or instructor is that the registered students may not actually be taking a test but having others take it for them. Because some students never come to the campus or meet with the instructional staff, cheating is of special

concern in distance education (Baggaley & Spencer, 2005), particularly because it has been shown that more active users of the Internet are more likely to use unethical practices (Underwood & Szabo, 2003). Cheating is also a concern in classroom learning, and McCabe (2005) has reported large recent increases in such cheating.

Various techniques have been proposed for dealing with cheating in distance education (Duffy & Kirkley, 2003). These include inserting random personal questions that only the student can answer, using proctored final examinations and registration, and other approaches for identifying students (Baron & Crooks, 2005; Shyles, 2002). The cheating issue is also the subject of discussion in forums on distance education (DeosL-@lists.psu.edu), in which it has been suggested that with the advent of optical recognition equipment in the near future, such cheating will be of less concern. Nevertheless, cheating remains a serious concern whether instruction is or is not distributed away from campus.

Implications of ADL for Educational Practice

Our late colleague Richard Snow once remarked that research on educational innovations often seems to be a random walk through a "garden of panaceas." Neither ADL nor distributed learning is a panacea for all educational ills. However, in addition to being unconstrained by the computer systems used, ADL and distributed learning generally are not constrained by the organization of schools or classroom approaches. One can easily imagine distributed learning technologies and ADL instructional objects being used by students in a variety of classroom arrangements, such as situated learning (Paavola, Lipponen, & Hakkarainen, 2004), anchored instruction (Cognition and Technology Group at Vanderbilt, 1997), or facilitating communities of learners (Brown & Campione, 1994).

Distributed learning technologies and ADL objects can also support teaching in relatively traditional classrooms. For example, an instructional object could be assigned to a whole class. Students could work on it in school as a whole class, in subgroups, by themselves, or after school as a research activity, with students working separately or networked together. Similarly, instructional objects could be referenced in curriculum guides, workbooks, and teacher's editions of textbooks.

The wide use of instructional objects in school settings will be aided by research findings and increased understanding of their instructional utilities. But these objects can be used now in schools, while that knowledge is being developed. The instructional arrangements favored by social constructivists are being implemented while evidence of their effectiveness is still being collected (e.g., Duffy & Kirkley, 2003; Paavola et al., 2004; Strijker, 2004). As instructional objects become ubiquitous in business, industry, government, and the military, it seems likely that they will be used in schools even as research dealing with their effectiveness and applicability continues.

One attractive aspect of ADL instructional objects is that students can retrieve them at a time when their curiosity has been aroused, or at a "teachable moment." Such moments generally occur when students are stimulated to acquire knowledge or competencies. Teachable moments are described in the literature dealing with a variety of educational contexts including education of pre-service teachers (Jones & Vesilind, 1996), mathematics education

(Mewborn, 1998), and skills instruction in language arts (Hinchey, Adonizio, Demarco, & Fetchina, 1999). The ready accessibility of ADL objects can help educators and students take best advantage of teachable moments.

The probability that ADL will affect education in the near, as opposed to distant, future was enhanced by an announcement that Microsoft products relevant to education would be fully SCORM compliant (Microsoft Corporation, 2006). Software is now available that permits teachers to easily create Microsoft Office documents for use with learning management systems that are SCORM compliant. The ease of use and the utility of this software and, most important, the extent to which it improves student learning are still to be verified by research, but its availability suggests that ADL will have an increasingly important impact on education.

The organization, staffing, administration, and budgeting processes and procedures for much of K–16 education are based on classroom metaphors that assume that learners will gather at particular times and in particular places to receive instruction, or participate in learning experiences. With its anywhere, anytime capabilities, ADL requires adjustments in these processes and procedures so that its benefits can be fully realized. These adjustments will be in addition to supporting the up-front costs and other demands on school resources required by ADL. Research with adequate cost models and well-defined cost elements is needed to examine whether there is a return on these investments and to determine the extent to which ADL's value for schools and learners may compensate for the initial investment costs.

Evolving Roles

ADL and anytime, anywhere instruction present some significant challenges requiring discussion and research. As frequently noted, the roles of students, teachers, and administrators are all likely to undergo significant modifications. Students will be able and expected to take more responsibility for their own learning. Teachers will have to guide and help students who are working independently and delving into areas in which some of them may develop expertise that rivals or exceeds that of their teachers. Administrators will need to adjust certification procedures for learners who acquire new knowledge and capabilities outside the standard curriculum prescriptions. We hope to encourage active discussion of these and other issues in the *ADL Newsletter for Educators and Educational Researchers*, which is freely available at <http://www.academiccolab.org/newsletter/ADLnewsletter.html>.

Needed Research

ADL has made substantial progress at the software engineering level. It has specified how instructional objects are to be packaged, accessed, launched, and linked to one another from a computational standpoint. But as commentators have noted (e.g., Chipman, 2003; Friesen, 2004), ADL needs to apply more serious attention to developing the learning capabilities that are its primary goal. ADL software engineering and instructional goals are interdependent. They must be coordinated and “harmonized” to achieve the ADL vision and its goals for anywhere, anytime learning. Typically, the promise of innovations outstrips the research on which they are based. ADL offers the opportunity for important research to realize its potential and to advance

instructional psychology. Some of the research opportunities offered by ADL are summarized below.

Research is needed to determine whether the provision of readily accessible instructional materials by ADL improves students' learning or enhances adaptations to their learning needs. More cost-benefit studies of ADL are needed, as are ways to quantify some of the benefits outlined above. We also need to know whether and to what extent ADL improves students' learning when it is used to augment the usual resources available in classrooms. Similarly, we need to determine whether the opportunity to capitalize on teachable moments through ADL is realized: Does the availability of instructional objects arouse students curiosity and help them solve problems of interest to them, or does it simply help them complete assigned schoolwork more rapidly than they could in environments without ADL?

Research is also needed to determine which data elements in the student model (prior knowledge, metacognition, motivation, etc.) are most useful for tailoring instruction to the needs of learners. Research is required to improve the mixed-initiative dialogues between students and instructional technology and to determine the extent to which these dialogues improve students' learning in comparison with ordinary classroom interactions. Studies of how to better adapt such interactions to individual students' needs, as well as how to assemble instructional objects to create these interactions, are also needed.

Debate continues on the adequacy of current models for identifying learning objects with sufficient descriptive data so that developers and instructors can efficiently locate the needed objects (Plodzien, Stemposz, & Stasiecka, 2006). We do not yet have an adequate number of working examples of instructional objects or instances of their use to enable researchers to weigh outcomes and benefits, identify best practices, and establish workable definitions; it remains for future research to clarify these issues. The development of the Semantic Web will help, but again, research will be needed to determine how best to use its capabilities to enhance the effectiveness of educational applications.

Interest in reusable learning objects is substantial and growing (e.g., Clyde, 2004; McGreal, 2004; Strijker, 2004). Research is needed to determine how human knowledge can adequately be represented in digital technology, to clarify the limits of such representations, and to reveal their best uses in tailoring instruction to help develop the potential of individual learners.

Assessment can become more continuous and unobtrusive as research determines the most useful variables in ADL's student model. They may use data such as a learner's vocabulary, use of technical information, level of abstraction, clustering (chunking) of concepts, and inferred hypothesis formation, among others. The feasibility of such assessment, how best to conduct it, and the extent to which it should be done all remain issues for education research. The design and development of optimal assessments that capitalize on distributed learning capabilities is a challenge requiring the collaboration of educators, instructional designers, and the testing community. These groups must work together to integrate evaluation, instruction, and instructional design, as Baker (2003), among others, has recommended. Finally, more attention to the costs and cost-effectiveness of anywhere, anytime learning is needed.

A Final Word

We have briefly described distributed learning and the ADL initiative and suggested some of their implications for K-16 education. We suggest that plans for the future of education need to account for the impact of ADL and all forms of distributed, anytime, anywhere learning and their ability to augment both formal and informal learning. The involvement of educators and education researchers is essential for shaping the development and implementation of distributed learning and ensuring adequate attention to both its opportunities and its challenges. We hope that educators and education researchers will be encouraged to address these issues, so that the benefits of ADL may be as fully realized for K-16 students as they are for those receiving training in government and industry.

NOTES

We wish to express our gratitude to the editors of *Educational Researcher's* Research News and Comment section and to the reviewers for their many helpful and insightful comments on this article. The findings, views, and conclusions expressed are strictly those of the authors and do not represent official positions of the U.S. government or the U.S. Department of Defense.

¹ADL also includes job aiding, performance aiding, and decision aiding in its definition of learning, but those applications are not discussed here.

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AUTHORS

J. D. FLETCHER is a senior researcher at the Institute for Defense Analyses, 4850 Mark Center Drive, Alexandria, VA 22311; fletcher@ida.org. His research interests include training, the design and evaluation of instruction using technology, and human performance analysis.

SIGMUND TOBIAS is a Distinguished Research Scientist at the Institute for Urban and Minority Education, Teachers College, Columbia University, Box 75, New York, NY 10027; stobi@aol.com. His research interests are metacognition, Web-based learning, and the achievement gap.

ROBERT A. WISHER is director of the Advanced Distributed Learning Initiative at the Office of the Secretary of Defense, OUSD(P&R) Room 1E525, 4000 Defense Pentagon, Washington, DC 20301-4000; robert.wisher@osd.mil. His research interests are training and skill retention.

Manuscript received May 1, 2006

Revisions received July 26, 2006, and November 2, 2006

Accepted January 8, 2007